U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

PRESSURE TRANSMITTERS

1. OBJECTIVE

The objective of this procedure is to determine limitations and characteristics of missileborne pressure transmitters.

2. BACKGROUND

The pressure transmitter is used to change a mechanical action caused by a pressure variation into a reference voltage proportional to the mechanical action. Installation of the device normally is accomplished in the missile guidance system to detect any deviation in desired flight condition.

The results of transmitter tests are used to determine the performance that can be expected from a pressure transmitter when installed in a missile guidance system. A description of several types of pressure transmitters is contained in Appendix A.

3. REQUIRED EQUIPMENT

a. Pressure Pump
b. Pressure Monitoring Gauge
c. Regulators
d. Ballast Tank
e. Vacuum Pump
f. A-C or D-C Signal Generator (whichever is appropriate)
g. Voltage Recorder and chart paper
h. Vacuum Tube Voltmeter (VTVM)
i. Appropriate Load Impedance
j. Resistance Bridge
k. Electrical Buzzer or Dither Vibrator
l. Test Panel as shown in Figure 3
m. Contact Resistance Measuring Circuit (as shown in Figure 4).
n. Visicorder and Chart Paper
o. Container of water (large enough for transmitter)
p. Aerosol Wetting Agent
q. Oscilloscope
r. Ohmmeter
s. Double Channel Recorder
t. 4-way Solenoid Valve
u. Manostat
v. Manometer
w. 1/4 inch tube (3 inches long)
x. Resistor equal to Transmitters load Impedance
y. 5 K resistor
z. Appropriate switches

BLANK PAGE

aa. Null Out Box (with 10 volt source)
bb. 28 volt, 5 amp, D-C Source
cc. Pressure Generator (controlled sine waveforms)
dd. 500 Volt Direct Current (d-c) Megger or equivalent
ee. Multiohmmeter
ff. 1000 Volt or Higher High Potential Tester
gg. Linear Graph Paper
hh. Straight Edge

4. REFERENCES

A. Second Edition, The International Dictionary of Physics and Electronics, D. Van Nostrand Company, Inc., Princeton, New Jersey
B. ASA Z32.13-1950, Abbreviations for Use on Drawings, American Standards Association, New York, N. Y. 1950
C. AFM 52-31, Guided Missiles Fundamentals
D. MTP 5-2-515, Missilebourne Pressure Altimeters

5. SCOPE

5.1 SUMMARY

The procedures outlined in this MTP are intentionally general to provide a coverage that will apply to various pressure transmitters while maintaining the degree of accuracy required by specification. Operating and physical characteristics that apply to a specific pressure transmitter can be obtained by referring to the applicable specifications (manufacturer's instructions or MTD's). The following tests are described:

a. Visual Examination - This test is conducted to determine any obvious defects, poor workmanship, damage in shipping, general appearance and conformity to military standards and specifications.

b. Case Leak - This test is performed to ensure that the case of the transmitter has been properly sealed.

c. Overall Sensitivity and Pickoff Resolution - This test is conducted to determine if the transmitter's sensitivity is continuous through the range of the transmitter and to determine the resolution of the pickoff.

d. Calibration - Linearity - This test is conducted to determine any variation to the ratio of input to output voltage.

e. Hysteresis - The purpose of this test is to determine the percent average hysteresis error.

f. Friction - The purpose of this test is to determine what percentage of a pressure change is required to overcome friction between wiper arm and resistive element of a potentiometer type pickoff.

g. Repeatability - The purpose of this test is to obtain a measure of the deviation of test results from their mean value.

h. Variation in Contact Resistance - This test is performed to determine the variation in contact resistance as the wiper sweeps across the windings.

i. Width of Potentiometer Wiper - If a potentiometer type pickoff is

used this test shall be conducted to determine the width of the wiper, number of windings spanned, and resistance shorted by the wiper.

j. Range End Points - The purpose of this test is to measure the exact range of the transmitter.

k. Zero Drift - This test is conducted to determine the amount of zero drift as a percentage of full scale output.

l. Transient Response - The purpose of this test is to determine if the transmitter yields the required percentage of response in a specific time when pressure is suddenly changed from a specified pressure to another value of pressure. Another purpose of this is to determine that oscillations in excess of specifications do not exist.

m. Overall Resolution - The purpose of this test is to determine the minimum change of pressure which will produce an effective output of the pickoff at various pressures throughout the range of the transmitter.

n. Frequency Response - The frequency response tests are performed to obtain information about the dynamic character of the transmitter and the flatness of its transfer function.

o. Accelerated Life Testing - This test is performed to determine whether failure will occur after many cycles of pressure application and removal.

p. Resistance, Insulation, and Dielectric Tests - These tests give a quick indication of electrical malfunction or component failures.

5.2 LIMITATIONS

Due to the large variety of pressure transmitters this MTP is limited in scope to those which are commonly found in missile system applications.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. The input and output instrumentation shall be approximately 10 times the accuracy of the function being measured.

NOTE: Accuracies of the test instrumentation will be in the appropriate manuals supplied by the manufacturer of the instrument.

b. Tests shall be in the order of the least destructive test first so that the effects of one test will not damage the specimen and adversely affect subsequent tests.

c. Data or information from prior test shall be available for subsequent tests.

d. Test data shall be obtained and presented in a logical order to ensure that the complete test history of a transmitter is available for analysis.

e. A record book or log shall be maintained on each specimen.

f. Identification information, operation time, test data, etc. shall be entered to provide a permanent history of the test.

g. All tests shall be conducted using the same instrumentation to avoid variation in data.

h. Instrumentation setups shall remain intact until there is no further requirement for a specific test.

i. Personnel conducting the test shall be thoroughly familiar with the test instrumentation and operating manual to ensure acquisition of valid data.

j. Limitations of the test specimen shall be known to prevent damage during tests.

k. Standard Operating Procedures (SOP) on safety shall be observed at all times to avoid injury to personnel and damage to equipment.

NOTE: There are certain conditions which make each measurement different. Therefore selection of the type of sensor and pickoff will be governed by the measurements to be performed by the transmitter. The large number of sensors and pickoffs in pressure transmitters, with variations, precludes a detailed procedure for each type.

l. The test procedures herein shall be performed under ambient conditions unless otherwise specified.

6.2 TEST CONDUCT

NOTE: All transmitters may not necessarily be subjected to all the tests discussed in the following paragraphs.

6.2.1 Visual Examination

a. Conduct a visual examination on all specimens upon receipt to determine and record the following:

1) Compliance with configuration, workmanship, identification markings
2) State of preservation during handling, packing and shipping

NOTE: Associated drawings and military specification shall be used as guides in conducting examinations.

6.2.2 Case Leak

a. When appropriate, connect the transmitter to the pressure system as in Figure 1 except the resistance bridge shall not be connected and pressurize to a specified pressure of dry air.

b. Immerse the transmitter in a container of water to which an Aerosol wetting agent has been added (0.25 percent by weight).

c. Allow the transmitter to remain submerged for one minute.

d. Observe all leaks which will appear as air bubbles escaping to the water surface.

e. Record the locations of all leaks observed.

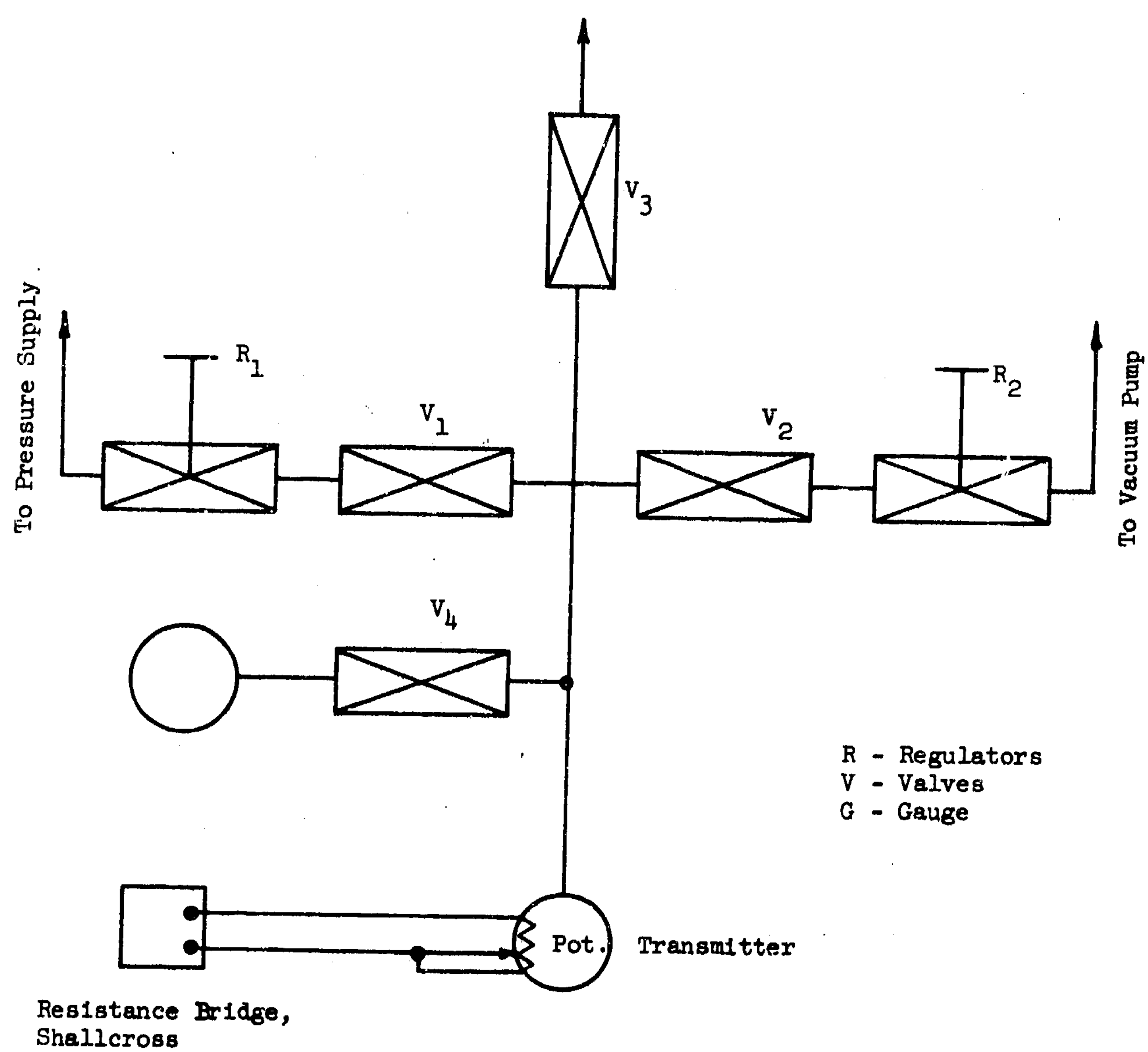

Figure 1. Typical Pressure System

6.2.3 Overall Sensitivity and Pickoff Resolution

a. Connect the transmitter to the pressure system (see figure 2)
b. Pressurize the transmitter to maximum range.
c. Seal off the pressure by closing all valves (in figure 2) V_1, V_2, and V_3.
d. Energize the pickoff with appropriate voltage (refer to specimens Schematic).

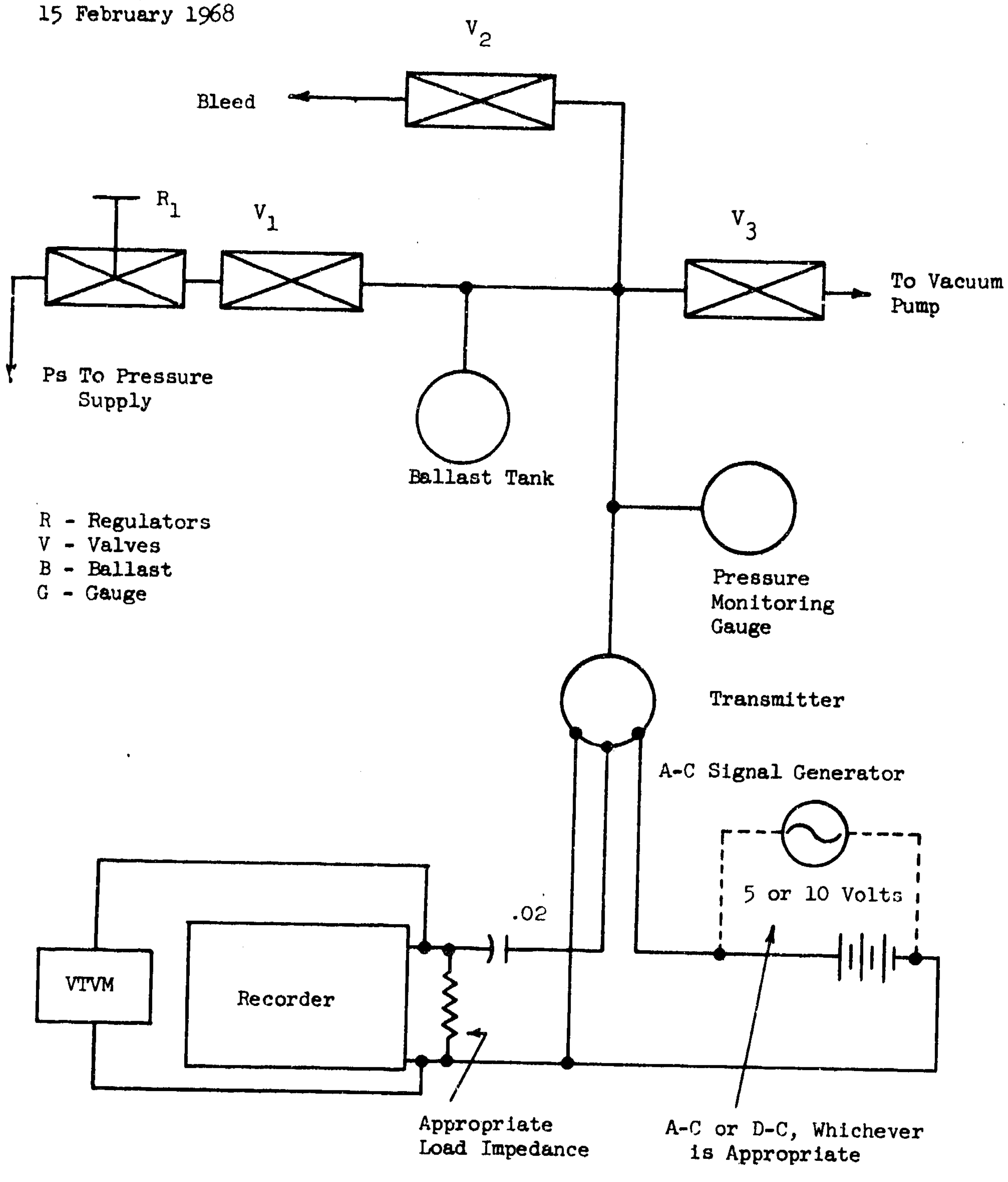

Figure 2. Typical Pressure System Used in Pickoff Resolution Test and Sensitivity Resolution Test

NOTE: The output is connected to a recorder which is calibrated so that the stylus deflection is some factor of the entering voltage.

e. While operating the recorder chart at slow speed open the bleeder valve, V_2, a small amount.

f. Read the pressure change (ΔP) and observe the voltage change (ΔE) at ten equally spaced intervals throughout the pressure range of the transducers.

g. Record these changes (ΔP and ΔE) in tabulated form.

h. Continue reducing the pressure to atmospheric pressure.

i. Gradually open the bleeder valve such that a more constant exhaust flow will be maintained and will give a more symmetrical record on the recorder.

j. When atmospheric pressure has been reached, seal off the system from the atmosphere by closing valves V_2 and V_1.

k. By means of the vacuum pump, which has been connected into the system prior to the start of the test, decrease the pressure slowly by slightly opening valve V_3.

l. Continue a slow decrease in pressure to obtain a higher vacuum, until no further deflection of the stylus occurs.

m. Stop the recorder, restore the transmitter to atmospheric pressure and remove the chart.

6.2.4 Calibration - Linearity

NOTE: Procedure described in this paragraph only applies to those transmitters which have a range both below and above atmospheric pressure.

6.2.4.1 D-C Potentiometers

a. Mount the transmitter on a test panel as shown in Figure 3.

NOTE: The panel incorporates a small electrical vibrator. This vibrator, when activated imparts a series of light taps to the panel on the order of .06g at 60 or 120 cycles per second (cps). The object of the vibrator is to remove the effects of friction from the transmitter.

b. Connect the transmitter to a pressure system as shown in Figure 1.

c. Potentiometer pickoff resistance readings shall be taken and recorded before and after buzzing the vibrator.

d. The output of the transmitter is connected to a resistance bridge and only resistance ratios $\left(\frac{\text{output resistance}}{\text{total potentiometer resistance}}\right)$ shall be taken and recorded with the potentiometer deenergized.

NOTE: All resistance readings shall be taken before and after buzzing the vibrator.

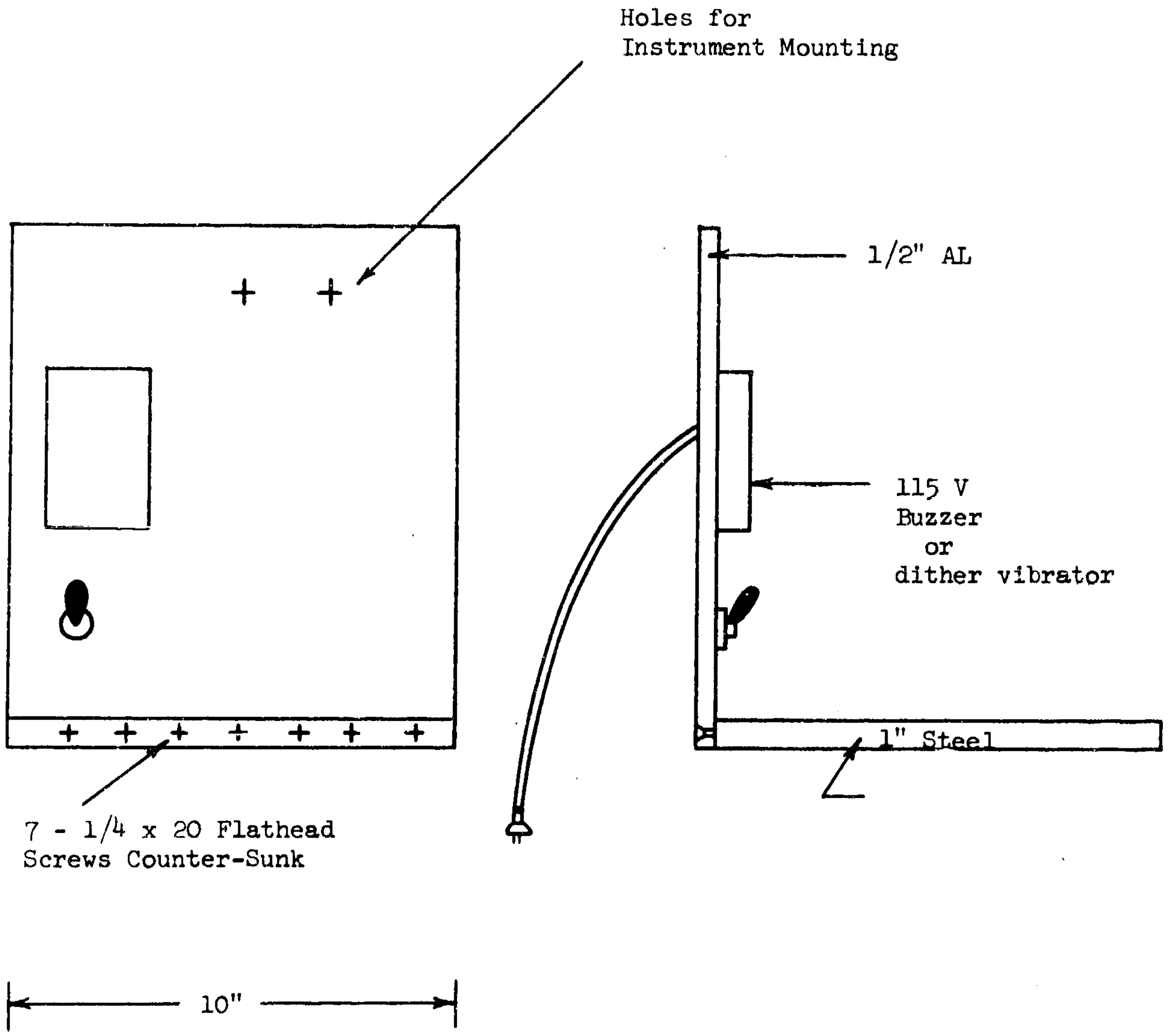

Figure 3. Typical Test Panel Used in Calibration - Linearity Test and Sensitivity Resolution Test

e. Pressure points where checks are to be made shall be in steps varying in increments (10-15 spaced intervals) to give a representative curve over the range of the transmitter. The intervals at the lower part of the range near zero input shall be smaller.

NOTE: Care shall be taken not to overshoot the selected pressure (interval check points) levels when making pressure changes. To do so would destroy the effects of any hysteresis.

f. Decrease the pressure to zero.
g. Read and record resistance values.
h. Increase the input pressure in steps of the selected pressure intervals recording input pressure and output resistance readings at selected calibration or check points until the maximum range has been reached.
i. Start decreasing the pressure making stops and recording output resistance readings at the identical pressure intervals as was done during increasing pressures.
j. Continue this reverse operation until zero input or the starting point is reached.
k. Restore the system to atmospheric pressure.
l. Adjust the pressure to the next lower level from the original starting point; by means of the vacuum pump, continue decreasing pressure and recording resistance readings until the minimum pressure level has been reached.
m. Then increase the pressure and record resistance at original starting point.
n. Restore the system to atmospheric pressure.
o. Conduct a minimum of three identical tests.
p. Disconnect the resistance bridge.
q. Connect an appropriate DC volt meter to the pressure transmitter output.
r. Energize the transmitter.
s. Repeat steps h through o. In place of resistance readings make voltage reading.

6.2.4.2 A-C Potentiometers

a. Disconnect the resistance bridge.
b. Connect a VTVM to the output of the pressure transmitter.
c. Energize the transmitter.
d. Repeat steps h through o of paragraph 6.2.4.1; in place of resistance readings.

6.2.5 Hysteresis

Data to be obtained for evaluation of hysteresis test is obtained during the calibration-linearity testing.

6.2.6 Friction

Data to be obtained for evaluation of friction test is obtained during calibration - linearity testing.

6.2.7 Repeatability

Data to be obtained for evaluation of repeatability test is obtained during calibration-linearity testing.

6.2.8 Variation in Contact Resistance

Variation in contact resistance tests shall be performed only on pick-offs which employ a wiper and resistive element, such as a potentiometer.

a. Connect a transmitter to a pneumatic system as shown in Figure 1.
b. Connect the same transmitter electrically to a contact resistance measuring circuit as in Figure 4 (see Appendix B).
c. The potentiometer wiper shall complete a full excursion across the active portion of the potentiometer at a rate of about three seconds for full range.

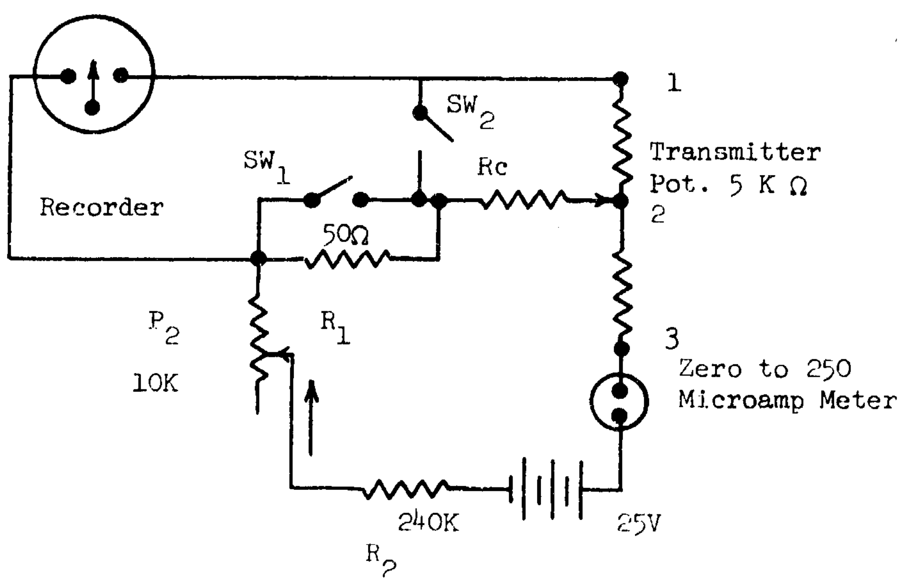

Figure 4. Typical Contact Resistance Measuring Circuit

d. The value of R_2 (Figure 4) shall be increased proportionately (P_1/R_2 = CONSTANT) with the resistance value of the pickoff potentiometer to maintain errors at negligible values.
e. The pickoff potentiometers never have a large current carrying capacity and the manufacturers specifications shall be consulted to avoid damaging or overheating the potentiometer.

NOTE: RC, shown in Figure 4, represents contact resistance which may exist between wiper and the coil.

f. Using Figure 4 as a typical contact measuring circuit, record the current distribution, when the potentiometer is positioned on terminal (zero input), as follows:

1. SW_2 open, SW_1, closed, P_2 centered
2. Total R of circuit = 240K + 5K + 5K = 250 K ohms (where K equals 1000)
3. I_c = 25 volts/250K = 1 x 10^{-4} amperes (amps)= 100 microamperes(μa)
4. Close SW_2, voltage across recorder (V_r)= 0.000 volts
5. SW_2 closed, SW_1, open, V_r = 100 μa x 50 ohms - 5.0 mv= 10 millimeters (mm) of deflection when recorder calibration = 10mv/20mm.

g. Be certain that the recorder is so calibrated that the above relations are obtained.

h. Now that the recorder is calibrated, close sw_1, and open sw_2, real contact resistance shall now be read and recorded.

NOTE: This resistance may be on the order of 2 or 3 ohms (200 or 300 microvolts (μv) and the recorder might not detect this small value.

i. Close SW_1, and open SW_2

j. Start the recorder and cause the potentiometer wiper to sweep across the full length of the coil by slowly varying the input pressure.

k. The recorder will begin to record spikes indicating changes in contact resistance. Record the amplitude of the largest spike.

l. With the potentiometer wiper positioned on terminal 3 (full range input); P_2 centered, record the following current distribution.

1. SW_2 open and SW, closed
2. Total R of circuit = 240K + 5K = 245 ohms
3. I_c = 25/245K = 1.02 x 10^{-4} amp = 10 μa
4. With SW_2 closed and SW open
5. V_r 10μa x 500 ohms = 5.1 mv.

6.2.9 Width of Potentiometer Wiper

This test shall be performed only on potentiometer type pickoffs.

NOTE: Should the transmitter have more than one identical pickoff, it is only necessary to conduct this test on one potentiometer.

a. Connect the transmitter to a pressure system as in Figure 1.

b. Pressurize the transmitter a small amount until the wiper changes position.

c. Measure and record the resistance again.

d. Repeat steps c and d twice.

e. If the three resistance readings are the same, record this value.

If they are not, then record the smallest value.

f. Connect an ohmmeter to the wiper and the lower end of the potentiometer.

g. Increase the input pressure until a further increase in pressure does not reflect any further resistance change. The nonactive portion of the potentiometer has now been reached.

h. With the wiper no longer contacting the active portion of the potentiometer thereby shorting out windings, measure and record the resistance.

NOTE: The resistance should be a little higher than that recorded in step f.

6.2.10 Range End Points

a. Connect the transmitter as in Figure 1 except that the pickoff shall be connected to a visual readout such as a recorder or oscilloscope.

b. By means of vacuum pump lower the pressure until no further change is observed on the readout. This represents the low end, end point.

c. Read and record the pressure in psi.

d. Return the system to atmospheric pressure.

e. Gradually apply an increasing pressure until the readout again does not reflect any further increase. This represents the high end, end point.

f. Again read and record the pressure in psi.

g. Restore the transmitter to normal atmospheric pressure.

6.2.11 Zero Drift

a. Connect the transducer to the pressure system see (Figure 1).

b. Reduce the pressure until zero pressure is being applied zero should be observed on the readout.

c. Record the output at 5, 10, and 15 second intervals and at one minute intervals thereafter for five minutes.

6.2.12 Transient Response

It is considered to be difficult to set up general procedures for determining transient response characteristics of pressure transmitters when there exists such a wide and varied assortment of these airborne instruments. For this reason, a good approach in discussing the subject of transient response will be set up and assume a hypothetical, but typical, instrument and treat detailed test procedures in an example case.

Accordingly, assume that the following parameters describe the transmitter under discussion:

a. A pressure transmitter measuring absolute pressure values in pounds per square inch, absolute, (psia).

b. Range, 14.92 (atmospheric) to 69 psia.

c. Assume that a specification requirement is such that the transmitter is required to yield a 90 percent response within 0.5 second when the pressure is suddenly bled off of pressurized from full range (i.e., from 69 psia) to atmospheric.

d. Assume that there should not exist any oscillations in excess of the equivalent of 25 ohms of potentiometer resistance, for a period of one second after initiation of the above mentioned pressure change.

e. Potentiometer normal excitation voltage is 10 volts d-c.

A test procedure designed to accomplish evaluation criteria commensurate with the previously described typical pressure transmitter is given in steps a. through j. of this paragraph.

NOTE: If the proposed method proves unsatisfactory in that the pressure is not exhausted or vented quickly enough, an alternate method may be employed. The alternate method incorporates depressurizing by suddenly severing the exhaust hose line by means of a sharp instrument such as an ax.

a. Connect the transmitter in accordance with the diagram shown in Figure 5.

b. Adjust channel A of the recorder such that a 28-volt d-c signal will deflect stylus about 20 mm.

c. Open V_1. Open passage between the pressure source and the vents of cylinders 1 and 2 of the Barksdale valve, V_2, by leaving switch SW_1 open.

d. Adjust channel B of the recorder such that 69 psia will deflect the stylus 23 mm. At this calibration, 1 mm = 3 psia. The calibration can be made by varying the pressure by means of R_1.

NOTE: Be sure that the stylus is on center when the pressure is at atmospheric and zero equilibrium exists between the null-out box and the transmitter output.

e. After zero equilibrium has been established, adjust the input pressure to the transmitter for exactly 69 psia as read on G. The recorder should read 23 mm.

f. Start the recorder chart and have the chart speed set for 100 mm per second.

g. Close SW_1 and after 3 or 4 seconds.

h. Stop the recorder chart.

i. Restore the pressure to zero by adjusting R_1, and then open SW_1.

j. Tear off the chart and analyze as described in data reduction and presentation.

k. Conduct two more tests, steps a through j of paragraph 6.2.1.2.

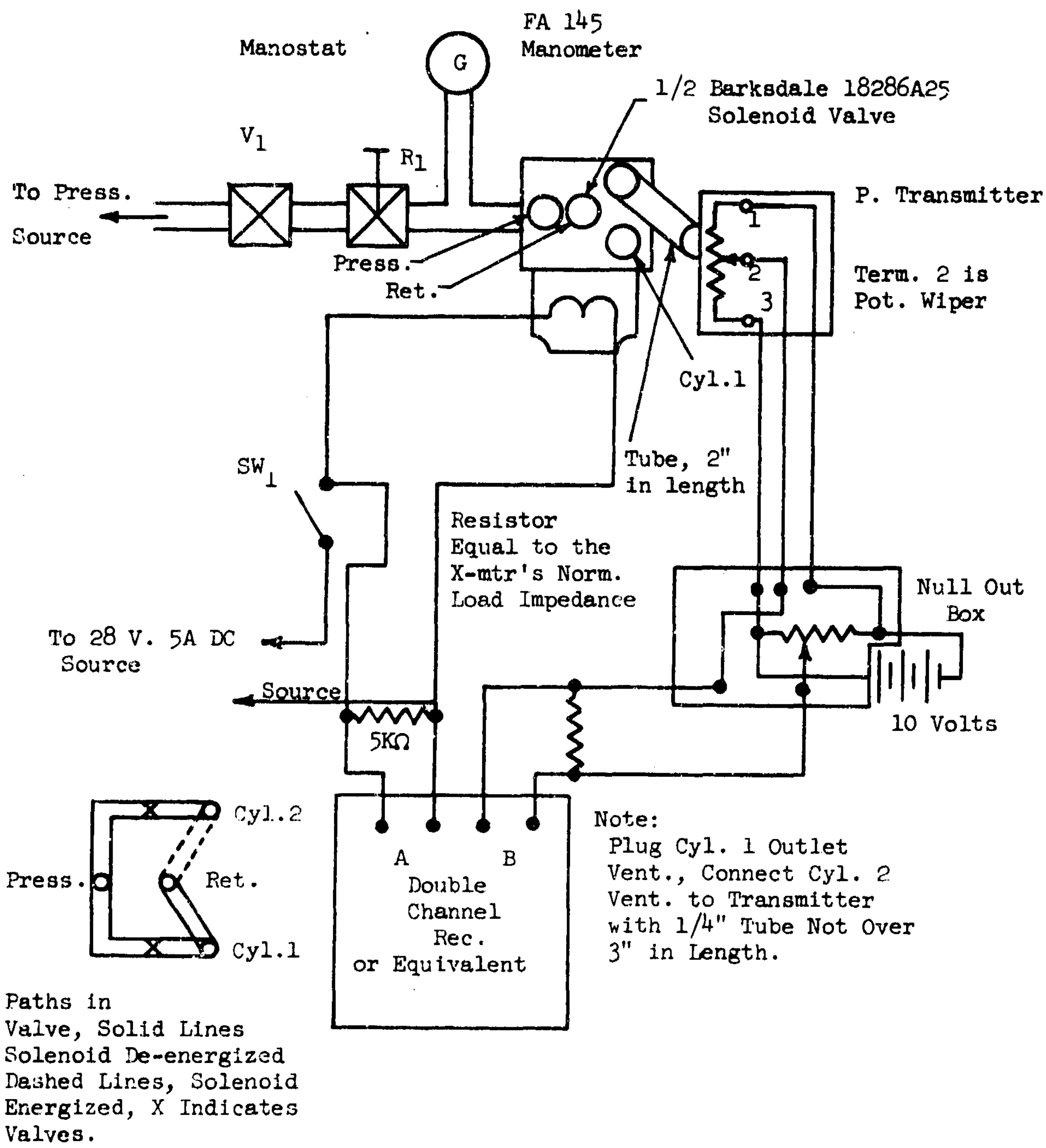

Figure 5. Typical Transient Response Test Configuration.

6.2.13 Overall Resolution

a. Mount the transmitter on a test panel as shown in Figure 3.
b. Connect the transmitter to a pneumatic and electric system as shown in Figure 1.
c. Connect the variator to the pressure vent of the transmitter and the readout instrument to the output of the pickoff.
d. Open the system to atmospheric pressure by opening V_3 and adjusting R_1 for atmospheric input.
e. Operate the panel buzzer to eliminate the effects of friction.
f. Read and record as P_1, the pressure input as read by the gauge G (see Figure 1)
g. Note but do not record the output resistance as read on the resistance bridge.
h. Close the bleeder vent and adjust R_1 until a resistance change is noted on the readout bridge.
i. Read the new pressure as indicated on G and record as P_2.
j. Restore the system to atmospheric pressure and repeat steps a-i two more times.
k. Repeat steps a-h for two pressures other than atmospheric.

6.2.14 Frequency Response

6.2.14.1 High Range Transducers

NOTE: To conduct a frequency response test on transmitters of high range (50 psi or more) is a difficult task requiring complex and expensive equipment.

a. Preparation

1) Connect the transmitter equipment capable of generating controlled sinusoidal pressure waveforms.
2) Connect the output of the transmitter to a recorder.
3) Connect the input to an oscilloscope.
4) Obtain the frequency spectrum of the transmitter from its specification requirements.
5) This frequency spectrum shall be divided into ten equally spaced intervals (including the lowest and the highest frequencies).
6) The sine wave of pressure shall have a static test pressure which is the arithmetic midpoint of the transducers pressure range as its center.
7) The maximum peak to peak dynamic pressure shall be the range of the transducer as specified in its specifications.

b. Test Conduct
1) Apply the pressure waveforms at the ten equally spaced intervals of the frequency spectrum.
2) Observe the amplitude of the waveform on the oscilloscope and keep the amplitude constant.

3) Record the input amplitude, all chart speeds, pressure ranges, frequencies and amplitudes on charts.

6.2.14.2 Low Range Transducers

Pertaining to low range (zero to 50 psi) the reader is referred to MTP 5-2-51/ Missileborne Pressure Altimeters. That MTP describes a frequency response test applicable to altimeters but similar test procedures can also be applied to low range pressure transmitters.

NOTE: It is important to determine the frequency at which the transmitter's sensing element is resonant. This determination shall be made during the vibration portion of tests conducted under the heading "Tests Under Specified Environments", paragraph 6.2.15.

6.2.15 Tests Under Specified Environments

Environmental tests are those tests which are conducted on the specimen at other than laboratory ambient conditions including vibration tests. There are two general methods, described as follows:

6.2.15.1 Method One

a. Subject the specimen to the specified environment

b. Compare the results to similar tests which were conducted under normal ambient room conditions.

c. Determine and record the extent of degradation, if any, that the specimen suffers while operating under the environmental conditions.

6.2.15.2 Method Two

a. Subject the specimen to an environment.

b. Conduct operational tests on the specimen under room ambient conditions.

c. Determine and record whether the specimen suffered any permanent damage by having been exposed to the environment.

NOTE: 1. Environmental tests shall be conducted in accordance with the applicable MTPs.

2. During the vibration portion of these tests the frequency at which the transmitter's sensing element is resonant shall be determined and recorded.

6.2.16 Accelerated Life Testing

Accelerated life testing is primarily for potentiometer type transducers or other transducers which may fail after many cycles of pressure application and removal.

a. Connect the transmitter to the same equipment used for the frequency response test paragraph 6.2.13.

b. The pressure cycling rate shall be 1000 cycles per second.
c. One run shall be performed to failure or 10^6 cycles.
d. If failure occurs record the number of cycles for failure.

6.2.17 Resistance, Insulation, and Dielectric Tests

These tests are conducted to obtain a quick indication of electrical malfunction or component failures.

6.2.17.1 Preparation

a. Caution shall be used when making high voltage resistance and dielectric tests to guard against the possibility of damage from high voltage being applied to susceptible components such as diodes and transistors.
b. MPD's and/or military specifications shall be used as references to establish guidelines for these tests.

NOTE: Test shall not be limited to these specifications if more thorough investigations are warranted.

c. The specimen shall be completely deenergized and left in the test locality for a sufficient length of time to allow parts to attain ambient temperatures.
d. Record the room temperature adjacent to the unit.
e. Point to point resistance values of all internal circuitry shall be measured and recorded at connecting plug pins.

6.2.17.2 Insulation Tests

a. Connect a 500 volt direct current (d-c) megger or equivalent between the internal circuits and the case and between isolated circuits and read and record the resistance values.

NOTE: Care and good test practices shall be exercised to prevent damage to any diodes or transistors which may be in the circuitry.

6.2.17.3 Resistance Tests

a. Multiohmmeters or bridgetype resistance measuring devices shall be connected to internal and external electrical circuits and parts and resistance values read and recorded.

NOTE: All critical resistance values shall be measured with a bridge ohmmeter and recorded.

6.2.17.4 Dielectric Tests

a. Dielectric tests shall be made at or near the end of the test

program to avoid possible damage to the specimen which could invalidate other tests performed.

b. A 1000-volt or higher high potential tester or equivalent shall be connected between isolated circuits and resistance values read and recorded.

NOTE: 1. Caution shall be exercised regarding semiconductors.
2. This type of instrument is designed so that if an insulation breakdown should occur, the specimen under test sustains no damage.

6.3 TEST DATA

6.3.1 Visual Examination

a. Record the following:

1. Compliance with configuration, workmanship, identification markings.
2. State of preservation during handling, packaging and shipping

6.3.2 Case Leak

Record the location of all leaks observed.

6.3.3 Overall Sensitivity and Pickoff Resolution

a. Record in tabulated form pressure changes (ΔP) each time a voltage change ΔE is observed.

b. Recorder chart shall be removed for analysis.

6.3.4 Calibration and Linearity

6.3.4.1 D-C Potentiometers

a. Potentiometer pickoff resistance readings shall be taken and recorded before and after buzzing the vibrator.

b. Record resistance values at starting point.

c. Record resistance ratios $\left(\frac{\text{output resistance}}{\text{Total potentiometer resistance}}\right)$ from step h. of paragraph 6.2.4.1.

d. Record output resistance readings and input pressure readings at selected calibration or check points from step i of paragraph 6.2.4.1.

e. Record output resistance readings from step j. of paragraph 6.2.4.1.

f. Record the resistance readings from step m. paragraph 6.2.4.1.

g. Record all voltage readings from steps h-o.

6.3.4.2 A-C Potentiometers

a. Record data as specified in step a-d of 2.4.1.

b. Record the output voltage read on the vacuum tube voltmeter (VTVM).

c. Record data as specified in steps h-o of paragraph 6.2.4.1

6.3.5 Hysteresis

The data recorded for calibration-linearity shall be used to calculate hysteresis.

6.3.6 Friction

The data recorded for calibration-linearity shall be used to calculate friction.

6.3.7 Repeatability

The data recorded for calibration-linearity shall be used to calculate repeatability.

6.3.8 Variation in Contact Resistance

Record the following:

a. Current distribution from step f. of paragraph 6.2.8
b. Contact resistance
c. Amplitude of the largest spike on the recorder chart
d. Current distribution from step 1 of paragraph 6.2.4

6.3.9 Width of Potentiometer Wiper

a. Record the smallest value of resistance measured when pressurizing transmitter by small amounts.
b. Record the resistance measured when wiper is no longer contacting the active portion of the potentiometer.

6.3.10 Range End Points

Record the pressure in psi at the low end point and the high end point.

6.3.11 Zero Drift

Record the output at 5, 10 and 15 second intervals and at one minute intervals thereafter for five minutes.

6.3.12 Transient Response

Obtain recorder charts for three identical tests.

6.3.13 Overall Resolution

Record pressures P_1 and P_2.

6.3.14 Frequency Response

6.3.14.1 High Range Transducers

a. The input amplitude, all chart speeds, pressure ranges, frequencies and amplitudes shall be recorded on the charts.

b. Recorder charts shall be removed and kept for analysis.

6.3.14.2 Low Range Transducers

Data shall be collected and recorded as described in MTP 5-2-515 (Only for transmitters of very low range).

6.3.15 Tests Under Specified Environments

Record the frequency at which the transmitter's sensing element is resonant.

6.3.15.1 Method One

Record the extent of degradation, if any, that the specimen suffers while operating under environmental conditions.

6.3.15.2 Method Two

Record whether the specimen suffered any permanent damage by having been exposed to the envrionment.

6.3.16 Accelerated Life Testing

The number of cycles for failure shall be recorded.

6.3.17 Resistance, Insulation, and Dielectric Tests

6.3.17.1 Preparation

Record the room temperature adjacent to the unit.

6.3.17.2 Resistance

Record all resistance values measured.

6.3.17.3 Insulation

Record all resistance values measured.

6.3.17.4 Dielectric Tests

Record all resistance values measured.

6.4 DATA REDUCTION AND PRESENTATION

All test results shall be compared to Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR) and Technical Characteristics (TC).

6.4 DATA REDUCTION

6.4.1 Visual Examination

No additional data reduction necessary

6.4.2 Case Leak

No additional data reduction necessary

6.4.3 Overall Sensitivity and Pickoff Resolution

a. Referring to the data obtained in paragraph 6.2.3 divide each ΔE by the ΔP corresponding to it.

b. Average these ten values.

c. Record this average $\Delta E / \Delta P$ as the overall sensitivity of the transmitter.

NOTE: The expression $\Delta E / \Delta P$ is equivalent to volts per unit pressure (such as pounds per square inch, gage, (PSIG)).

d. Calculate the pickoff resolution for potentiometer types as follows:

$$\frac{1}{N} \times 100$$

where: N is the number of windings or turns obtained from the specimens schematics or by counting the number of pips caused by a stylus deflection for each winding.

e. For A-C type pickoffs analysis of the chart will reveal t! resolution.

NOTE: A-C type pickoffs generally have infinite resolution.

6.4.4 Calibration-Linearity

a. Average the three resistance readings obtained in paragraph 6.2.4

b. From these averaged readings, plot a linearity curve of pressure in pounds per square inch (psi) versus resistance on linear graph paper.

c. In plotting the linearity curve mentioned above, indicate the data obtained under conditions of increasing pressure by a plot point enclosed by a circle, thus ⊙.

d. Plot point data obtained under conditions of decreasing pressure shall be indicated by inclosing that point within a triangle, thus △ .

e. Draw the most favorable straight line through the plotted points.

f. On the same chart plot the plus and minus tolerance envelope as obtained from the applicable military specification.

g. Observe and record whether or not the most favorable line falls within the permissible tolerance envelope.

6.4.5 Hysteresis

a. Referring to the data obtained in paragraph 6.2.4 and 6.4.4 determine the points of greatest deviation between resistance readings (taken after buzzing) at like calibration points under conditions of increasing (⊙) and decreasing pressure (△).

b. Divide the difference of the greatest resistance deviation found above by the total pickoff resistance obtained in paragraph 6.2.17.3.

c. Record the quotient as percent average hysteresis error.

6.4.6 Friction

a. Refer to the data in paragraph 6.2.4 and 6.4.2 and determine the greatest deviation between the resistance readings before and after buzzing at any calibration point. This difference represents a friction error.

b. Divide the difference of the greatest resistance found above by the total pickoff resistance obtained in paragraph 6.2.17.3.

c. Record the quotient as percent of average friction error.

6.4.7 Repeatability

a. Pertaining to the resistance ratios obtained after buzzing in paragraph 6.2.4, locate the greatest deviation of resistance values obtained under identical conditions at like calibration points.

NOTE: The identical conditions where the greatest deviation occurs may be found under either increasing or decreasing pressure but not both directions simultaneously, as this would not be under identical conditions. The greatest deviation shall be considered at two ⊙ points or at the two △ points. Never a ⊙ point and a △ point.

b. Divide the difference of the greatest resistance deviation found by the total pickoff resistance found in paragraph 6.2.17.3.

c. Record as the greatest repeatability error as a percentage.

6.4.8 Variation in Contact Resistance

Referring to data obtained in paragraph 6.2.8 the contact resistance shall be calculated as follows:

$$X\,\Omega = \frac{X\ \text{mm}}{10\ \text{mm}}\left(100\ \Omega\right)$$

where: X mm = amplitude of largest spike
$X\,\Omega$ = amount of highest contact resistance

6.4.9 Width of Potentiometer Wiper

a. Subtract the resistance value obtained in para. 6.2.9f from that obtained in para. 6.2.9i.

b. Divide the resistance measured in step i by the number of turns (N) determined in para. 6.4.3d. This indicates the resistance in ohms per wire.

c. Divide the ohms per wire obtained in step b above into the remainder resistance obtained in step a above.

d. Record the results of step e as the width of the wiper contact in terms of wires.

6.4.10 Range End Points

a. Determine the arithmetical sum of the two pressure values obtained in paragraph 6.2.10.

b. Record this sum as the full range or absolute pressure span (A_s) of the transmitter.

6.4.11 Zero Drift

The maximum deviation from zero recorded shall be used to determine zero drift. Compute what percentage of full scale out the zero drift is as follows:

$$\frac{\text{maximum deviation}}{\text{full scale output}} \times 100 = \text{zero drift}$$

6.4.12 Transient Response

a. With a straight edge, draw a line across both channels of the chart obtained in paragraph 6.2.12 step j superimposing the line over the deflection trace of channel A which occurred when sw 1, was closed. (step g.) Identify this line as L_1.

b. Scribe another straight line across the chart exactly 50 mm (0.5 second) from L_1. Identify this second line as L_2.

c. Scribe a third line across chart exactly 100 mm (1 second) from L_1; identify this line as L_3.

d. On channel B, locate the point along the curve scribed by the stylus where 69 psia minus 90 percent of 69 is indicated. The amplitude at this point will equal 23, minus 23 times 0.9 or 2.3 mm.

e. From the chart speed of 100 mm per second, determine the time elapsed between L_1 and the point where the amplitude was 2.3 mm. If the point occurred between L_1 and L_2, the response is within the specified requirements.

f. Determine the amplitude of oscillation one second after closing SW1 by reading, on channel B, the amplitude of the scribed curve where it crosses L_3. Then proceed as follows:

$$r = \frac{3\ AR}{A_s}$$

where:

r = resistance represented by oscillation

R = resistance of potentiometer (ambient) taken from paragraph 6.2.17.3

A_s = absolute span in psia from paragraph 6.4.10

A = Amplitude of oscillation in millimeters, taken from paragraph 6.2.12

The deviation:

C = recorder calibration in psia/mm = 69/23 = 3

C_c = total chart range in mm = $A_s/3$

U = ohms per chart mm = $R/A_s/3 = 3\ R/A_s$, then, $r = A\ U = 3\ AR/A_s$

6.4.13 Overall Resolution

a. Refer to the data obtained in paragraph 6.2.13 and determine the pressure change (Δp) by subtracting P_1 from P_2 i.e. $\Delta P = P_2 - P_1$.

b. Convert ΔP to psi if necessary.

c. Obtain an average of three ΔP's and record the value obtained as the resolution of the transmitter.

6.4.14 Frequency Response

Analyze the charts for frequency response by plotting a frequency response curve, amplitude ratio versus frequency.

6.4.15 Tests Under Specified Environment

No additional data reduction necessary

6.4.16 Accelerated Life Testing

No additional data reduction necessary

6.4.17 Resistance, Insulation, and Dielectric Tests

Compare all resistance values with values given in associated MPD's or schematics.

APPENDIX A

PRESSURE TRANSMITTERS

The type of transmitter considered herein is a pressure sensing device. The two terms, pressure transmitter and pressure transducer, are used and are considered to be interchangeable when measuring pressure. A transmitter or transducer can be defined as a device which when activated by power from one system, can supply power in the same or another form to a second system. In this MTP pressure is the power of one system and electrical output is the power in the other system.

The many pressure transmitters in use at the present time preclude a coverage of the entire field. Transmitters may be classified according to whether they are modulating or generating. Examples of the modulating types are variable inductance, variable capacitance and variable resistance. The generating types are photoelectric, thermoelectric, piezoelectric, and sometimes electron tubes.

In most applications, the pressure transmitter or transducer is used to change a mechanical action caused by a pressure variation into a reference voltage proportional to a mechanical action. The mechanical action (sensor) usually is provided by either a Bourdon tube or capsule type (bellows, diaphragm, etc.) pressure sensing element. The device which produces a useful signal from the sensor is the pickoff. The pickoffs most commonly used are the selsyn synchro, the potentiometer, and the reluctance or capacitance bridge types. Each type of pickoff incorporates design variations which make it suitable to specific applications where particular characteristics are needed.

APPENDIX B

TYPICAL CONTACT RESISTANCE MEASURING CIRCUIT

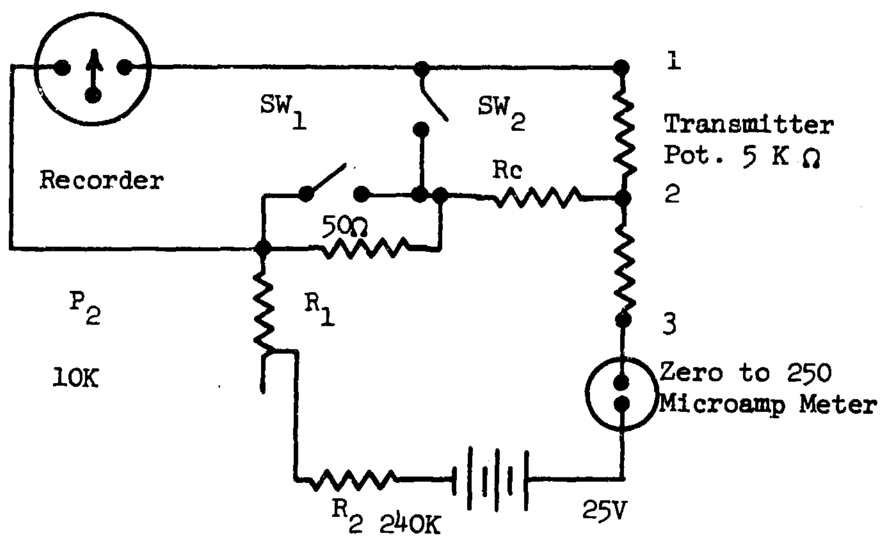

Figure 4. Typical Contact Resistance Measuring Circuit

Figure 4 shows a typical contact resisting measuring circuit. It shall be used in contact resistance tests. The amplitude of the contact resistance variation shall be recorded by a Honeywell Visicorder or equivalent. The recorder stylus deflection is adjusted and calibrated in terms of 500 ohms in which 50 ohms causes a stylus deflection of 10 millimeter (mm). In accordance with resistance values shown in circuitry of Figure 4 a 10-millivolt (mv) input to the recorder results in a stylus deflection of 20 mm, representing 100 ohms contact resistance. (1 mm stylus deflection = 0.5 mv = 5 ohms.)

Referring to Figure 4, note that a small error in measurement is introduced, depending upon whether the wiper is positioned on terminal 1 (zero input) or terminal 3 (full range input). This error is reduced to insignificance due to the large value of R_2 with respect to the transmitter's pickoff potentiometer.